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CONCERNING COLOR THEORIES AND THE GENERAL HARMONY OF COLOR.

BY GEORGE CURTIS WRIGHT.

THE science of optics, as advanced by Ptolemy in the Second Century, was undoubtedly the first treatise upon the subject in which the method of mixing colors, or colored lights, was mentioned. The advancement of this abstruse science has been slow, though volumes have been written and new theories proposed by the world's most noted physicists, dating from a very early period. We are still very far from realizing a true solution of the great question, as to which are, or should be, the three fundamental or primary colors upon which we can base our future work in color.

Most writers upon the subject of color are so widely at variance, that we presume a description of some of the more important theories advanced by them, may be new to the general art student.

A theory recently advanced by Hugo Magnus has a special interest on account of its originality.

It is to the effect that our sense of color has been developed during the last four or five thousand years. Previous to this period, it is assumed that our race was endowed only with a perception of light and shade. The evidence offered, however, is of a philological character, and tends to show that the ancients either distinguished, or described colors less accurately than the moderns. It is observed that the prehistoric races at present existing, and living in the same manner as their ancestors, are quite capable of discriminating colors, and evince much taste in their use. If our sense for light and shade is old, but that for color recent and still undergoing development, we should expect that it would require more time to recognize color, than appearances dependent simply upon light and shade. Professor Ogden N. Rood, of Columbia College, New York, has determined that forty billionths of a second answer as well for one as the other. The result of research in this direction by Le Blond, in 1735; Du Fay, in 1737; Meyer, in 1758; Lambert, in 1772; Sir Isaac Newton, Sir David Brewster, Wollaston, Helmholtz, Maxwell, Chevreul, Young and many others, thus developed many important facts, but each has his own pet fancy as to the three colors named as fundamental. Microscopy has revealed to us the nature of the nerve fibrils of the human retina. The little rods and cones of which it is composed are supposed to respond in some mysterious manner to all the colors of the solar spectrum, transmitting the sensations of color to the brain. Sir Isaac Newton labored under the false impression that light consisted of atoms, almost too fine to think of, but moving at the rate of 186,000 miles in a second. The undulatory theory (generally accepted as the true one) dispels the notion that light is matter shot toward us; it consists only of undulations or waves, which reach our eyes in somewhat the same manner as waves of water beating on a rocky coast.

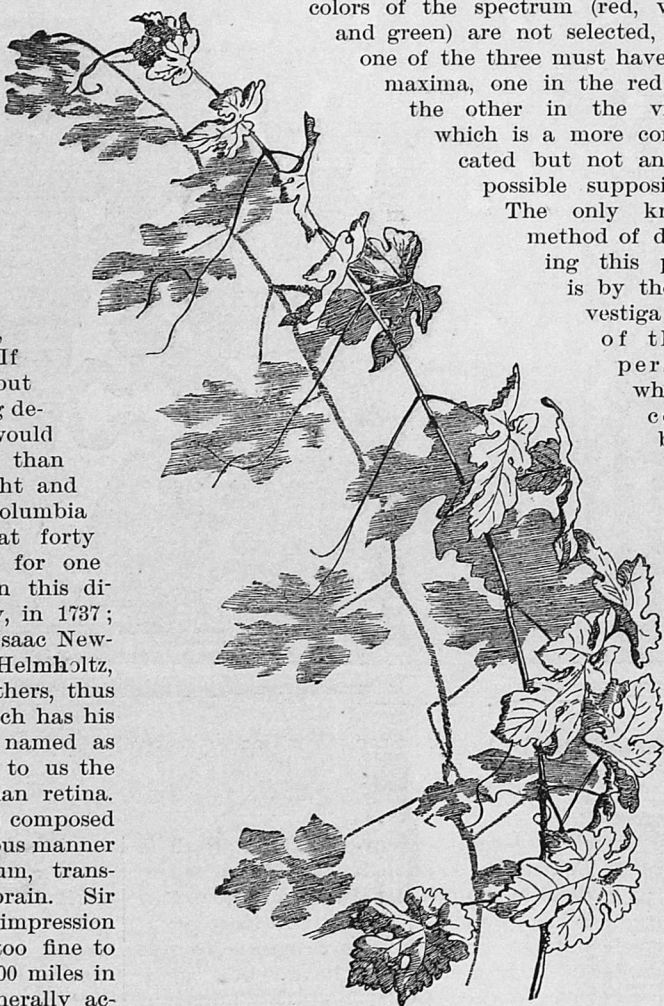
The theory of Thomas Young, as modified and set forth by Helmholtz and Maxwell, has engaged the attention of scientists for several years past. According to his reasoning, each minute elementary portion of the retina is capable of receiving and transmitting three different sensations. One set of these nerves is strongly acted upon by long waves of light, and produces a sensation we call red; another set responds most powerfully to waves of medium length, producing the sensation which we call green; and finally, the third set is strongly stimulated by short waves, and generates the sensation known as violet. The red of the spectrum then acts powerfully on the first set of nerves; but according to Young's theory, it also acts on the two other sets, but with less energy. The same is true of the green and violet rays of the spectrum; they each act on all three sets of nerves, but most powerfully on those especially designed for their reception. All this will be better understood by the aid of the accompanying diagram, which is taken from Helmholtz's great work on "Physiological Optics." On Fig. 1, along the horizontal lines 1, 2, 3, are placed the colors of the spectrum properly arranged, and the curves above them indicate the degree to which the three kinds of nerves are acted on by these colors. Thus we see that nerves of the first kind are powerfully stimulated by red lights, are much less affected by yellow,

still less by green, and very little by violet light. Nerves of the second kind are much affected by green light, less by yellow and blue, and still less by red and violet. The third kind of nerves answer readily to violet light, and are successively less affected by other kinds of light in the following order: blue, green, yellow, orange, red. The next point in the theory is,

that if all three sets of nerves are simultaneously stimulated to about the same degree, the sensation, which we call white, is produced. These are the main points of Young's theory, which was published as long ago as 1802, and more fully in 1807. Attention has been called to it by Helmholtz, and it is mainly owing to his labors and to those of Maxwell, that it now commands such respectful attention. Before making an examination of the evidence on which it rests and of its applications, it may be well to remember as Helmholtz remarks, that the choice of these three particular colors, red, green and violet, is somewhat arbitrary, and that any three could be chosen which, when mixed together, would produce white light. If, however, the end and middle colors of the spectrum (red, violet and green) are not selected, then

one of the three must have two maxima, one in the red and the other in the violet, which is a more complicated but not an impossible supposition.

The only known method of deciding this point is by the investigation of those persons who are color blind. The



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most common kind of this affection is color blindness to red, which indicates this color as being one of the three fundamental sensations.

But if we adopt red as one of our three fundamental colors, of necessity the other two must be green and violet or blue-violet. Red, yellow and blue, for example (the old and generally accepted theory) will not produce white light when mingled together, nor will they, under any circumstances, furnish a green. Red, orange, and blue or violet would answer no better for a fundamental triad. Color-blindness to green exists to some extent, though by no means so commonly as the other case. Hence, thus far, the study of color-blindness has furnished evidence in favor of the choice of Young, and its phenomena seem explicable by it. It would be necessary, to make the theory of Young more plain, to enter into a degree of detail (concerning color sensations which are not fundamental) that might seem tedious. In order to give more exactness to this theory, an accurate definition of the three fundamental colors is essential, for there is a great variety of reds, greens and violets. Helmholtz, as the result of his first investigation, selected a red not far from the end of the spectrum, and a full green and violet; in other words, the tints chosen were the middle and end colors of the spectrum. Maxwell, who made a series of beautiful researches on points connected

with Young's theory, was led to adopt as the fundamental colors a red which in the spectrum lies between the fixed lines C and D, and is distant from C just one-third of the distance between C and D. This is a scarlet red with a tint of orange, and is represented by some varieties of vermillion. His green is situated between E and F. This color finds among pigments an approximate representative in emerald green. Instead of adopting a full violet, Maxwell selected a violet-blue midway between the lines F and G, which is represented tolerably by artificial ultramarine blue. By subjecting the results of experiments on the spectrum to calculation, it is possible to fix on the position of one of the fundamental colors, viz., green. Thus Charles S. Pierce, using data given in Maxwell's paper, obtained for this color a slightly different result from that just mentioned. J. J. Muller conducted an important investigation on this subject by quite a different method, and also arrived at a somewhat different result for the position of the green. Again, Von Bezold reached a conclusion not differing much from those of Maxwell or Pierce. None of these results differ very greatly; in fact, the differences can hardly be well indicated in a spectrum the size of this page. All of these greens may be imitated by using the pigment known as emerald green, alone, or mixed either with a small quantity of chrome yellow or cobalt blue. The exact determination of the other two fundamental colors is a more difficult matter, so that even the advocates of Young's theory have not entirely agreed among themselves upon the exact colors, Maxwell taking ultramarine blue, Helmholtz and Muller violet, as the third fundamental. These fundamental colors are among the most saturated and intense of those furnished by the spectrum. If a normal spectrum is cast on a white wall in a room not carefully darkened, scarcely more than three fundamental colors will be discerned, red, green and blue-violet; the other tints can, with some difficulty, be made out, but at first sight they strike the unprejudiced observer simply as the places where the three principal colors blend together. Red is used without much difficulty in painting and decoration; the other two are more difficult to manage, particularly the green. The last color, even when subdued, is troublesome to handle in painting, and artists generally avoid it as much as possible, or admit it into their work only in the form of low olive greens of various shades.

When the tint approaches the fundamental green, and is at the same time bright, it becomes at once harsh and brilliant, and the eye is instantly arrested by it in a disagreeable manner. Young does not appear to have been the first who proposed red, green and violet as the three fundamental colors. In 1792 Wünsch was led to the same result by his experiments on the colored rays of the spectrum.

Young at first selected red, yellow and blue as the three simple color sensations, but subsequently modified his hypothesis, and adopted red, green and violet as the three elementary color sensations, showing that up to the date of this change of opinion all of his ideas upon the subject were hypothetical, and not based on any observations of his own or others. This change of opinion as to the three elementary colors was made on the basis of a misconception by Wollaston of the nature of his celebrated observation of the dark lines in the solar spectrum, and also on the basis of an erroneous observation made by Young in repeating Wollaston's experiment. Young subsequently tested his hypothesis of color sensation, and found that it was in accord with facts reached by experiment, and that these experiments then vindicated his hypothesis and raised it to the dignity of a theory.

STUDY OF FOLIAGE.

IN his guide to "Art Instruction in England," Mr. F. Edward Hulme gives the following good advice to beginners for drawing natural foliage:—"The beginner should have a simple spray of some bold form, like the laurel, but he must not be allowed to draw the leaves in a flat and diagrammatic way. The foreshortening will puzzle beginners tremendously at first; but a little timely explanation will soon help them. The pieces to be drawn must be placed in bottles of water before them; if the pupil is allowed to deal with them in his own way, he will put them on the paper beside him, and this at once gives them a flattened-out look which makes them easier to draw, but takes the life and beauty away entirely." Natural foliage is undoubtedly learnt best in this way, but teachers and pupils are both fond of reducing everything to the flat. It is to be regretted the study of natural foliage is not more encouraged in our schools of art, as it is one of the best exercises in the art of model drawing or drawing from the solid.—*Building News*.